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Analysis of Potential of International Inter-Cluster Cooperation in High-Tech Industries

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Abstract The article deals with the background and benefits of international inter-cluster interactions. Research shows that the cluster is the most effective form of innovative development based on the concept of innovation ecosystem, and intercluster international partnership is the most appropriate form of organization for the development of high-tech-based inter-sectoral cooperation and implementation of international projects. It is shown that the consideration of high-tech industry in the framework of the structural model as mega cluster means that the synergistic advantage can be seen only with a clear organizational structure and coordinated interaction of clusters. Analysis of necessity of inter-cluster interaction is considered on example of space industry. We propose tools for serching partners and assess the effectiveness of the scheme on the basis of inter-cluster interaction network approach and the results for the regional economy.

Keywords: *high-tech industries, international cooperation, cluster, synergy, technology transfer, innovation ecosystem*

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1. Introduction

The globalization of innovations leads to the necessity of exchange of international experiences and discussion of opportunities for international cooperation in the field of cluster development. Development of approaches to the further development of knowledge-intensive areas in order to achieve a cumulative effect in promoting the production cluster is a new task of science.

Emergence of the first cross-industry scientific and technical complexes for scientific and industrial problems was associated with high technology, namely nuclear energy and space technology.

2. Review of Theory

Analyzing the development of a new technological order, Kovalchuk M.V. [6] concludes that today it is necessary to produce again "means of production" for development of new technologies (NBIC-technologies). The necessity for this is a result of prolonged use of sectoral principle of industrial development that does not meet the high technology of the sixth order.

So in the XX century more complex, integrated, cross-sectoral technology of aircraft, ships and spacecraft have emerged. These complex objects of existing industry were created in sectoral economy and as a result of this synergy and mutual penetration of technology have not happen and is was only the addition of the additive results of various process industries.

Zvyagina E.M. [12] notes that the typology of clusters can be supplemented by the effects of inter-cluster interactions. This effect is manifested in the fact that the clusters as a whole or individual residents (companies and organizations) may interact with other types of clusters. In particular, such interaction can lead to the creation of fundamentally new competitive products through a synergistic effect. The greatest potential of intercluster interaction is in educational and infrastructure clusters to some extent capable of performing the functions provide for any cluster.

3. Methodology

The aim of the article is to analyze the theoretical foundations of the internationalization of cluster structures. To achieve the aim of article it is necessary to analyze the experience of foreign countries in clusters development, opportunities for international cooperation on the example of the space industry and space instrumentation.

These problems earlier have been solved in the framework of the intersectoral scientific and technical complexes both forms of the compound of science and industry, which have been designed to provide fast and efficient management in cycle "science - production" in priority areas of scientific and technical progress,

accelerate the development of new ideas and effective using them in practice. Formation of each interbranch complex due to the socio-economic conditions was a result of cooperation and integration of enterprises, organizations, institutions and industries. The effectiveness of cross-sectoral coordination of interactions were determined by the degree of production and economic development and innovation at meso- and micro level on the base of socio-economic development. However sectoral aspect was main in formation of complexes, which is partially passed and the clustering concept, dominated.

Today in the context of purpose of the article we suggest to use of analysis of the internationalization of clusters on the base of technological convergence (mutual influence and interpenetration and technologies) and the innovation ecosystem approach (set of conditions for the successful creation and development of innovation and technology transfer).

3. Research Results

It is widely recognized that cluster is the most effective mechanism of innovative modernization of production and development tool of high-tech industries. Leading condition of this is that the cluster may include a large number of different companies and members from different areas, which are combined in a flexible system that quickly responds to dynamic market conditions of the world economy and its industrial and technological cycles.

Consideration the high-tech industry in the structural model framework as megacluster means that the synergistic advantage can be achieved only within the clear organizational structure and coordinated interaction of different clusters. Cluster members are working together (co-working) to achieve common scientific and educational interests and meet the need of share of information, innovations and resources. For example, this intercluster interaction can be achieved through the creation of educational cluster by combining all scientific and educational units of the individual clusters in it.

At the same time flawed and defectiveness of autonomous cluster solutions (structures) consists of the following positions [7]:

- economy today face with the necessity to form a new way of development (first of all technological way), which doesn't provide for regional and sectoral boundaries (by analogy with the fact that today there are no information and linguistic boundaries). Therefore it is necessary to create such a business combination, which would integrate the disparate efforts to achieve scale effect in economic development, to create new systems of management of this development, to solve inter-regional and cross-sectoral industrial problems;

- existing economic theory and economic practice have not been able to solve problems of economy coordination in a globalized world. Development of education, science, innovation and industrial society is impossible without integrating them with the market. As a result it is impossible to allocate alliances, clusters, sectors of the economy and patterns of inter-branch cooperation on the assumption of the base of system of inter-regional and international division of labor and international cooperation. The system nature of market-based solutions consists in considering the identical branch and regional clusters and alliances in their interrelation and interdependence, including the impact on their innovation ecosystem;

- without addressing the consolidation and integration of clusters it is not possible to talk about consolidation and necessary for the economic development of regions, industries and nations. Only clusters, which are market-oriented and integrated with this function, can become a strategic form of production organization. Economic systems of this type is most conducive to the achievement of synergies cluster members on the base of reliable cooperative agreements, ensuring the formation of a system for implementing the order of the final product, innovation and the creation of their corresponding infrastructure, as well as the establishment of international relations;

- system of creation and market promotion of mono production is deprecated and demands for new solutions. New way of development of new production consists in providing integrated products to address the implementation of complex functions and consumer market applications. For example you can not only through the using of solar energy technologies solve the problem of power supply because it is necessary to consider all possible combinations of a wide range of alternative energy technologies and only such complex systems offer to market.

Geographical boundaries of high-tech cluster as a result of globalization of innovation represent economic realities and do not necessarily coincide with the administrative boundaries. At the same time its formal geographical boundaries assist interpersonal contacts and close cooperation between the agents of the domestic market, stimulate the accumulation of social capital which critical mass is the foundation of innovation development.

International aspect is essentially to examine with innovative hubs cooperation, which is the innovative system, formed in the ecosystem (Figure 1).

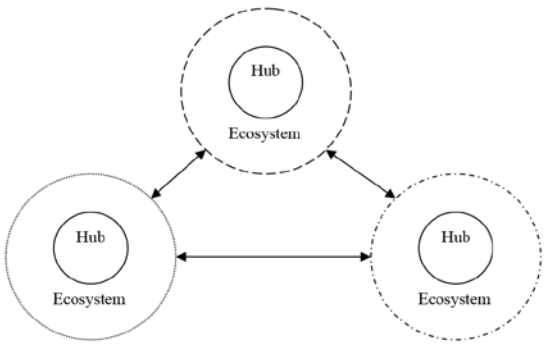


Figure 1. Scheme of global networking innovation ecosystems

Hub additionally to the development of its own innovative projects and infrastructure gives informational and consulting, scientific and technological, infrastructural and producing services for technologies transfer tasks solving.

Innovation hub functions simultaneously in the following capacities:

- consulting company which provides customer service necessary to attract foreign organizations and resources to meet the challenges of commercialization of innovation;

- scientific and educational institutions which able to organize and carry out research and educational programs etc.;

- owner / founder of one or more subjects of the innovation infrastructure that provide the necessary support commercialization;

- production company that can take to address the whole spectrum of the commercialization by providing of the necessary intellectual and financial resources to the development of a prototype or sample of the goods or services.

In high-tech sectors also a number of preconditions for inter-cluster information interaction [4] raise, among which should be noted:

- necessity of the exchange of technology standardization, unification and harmonization;

- necessity of commercializing of results of activities, ie, the presence of inter-cluster of commodity-money relations;

- necessity of information exchange due to the property relations between clusters;

- necessity to fulfill the social and budgetary functions of cluster members.

Thus the most effective delivers innovative communications (InCo), whose main purpose is encouraging open dialogue stakeholder innovation and cooperation with specialized approaches. This particular field of communication influence on economy and society in long-term and on the formation and development of innovative society.

Hub is oriented on communications between science, business and education, connected into "knowledge triangle":

- InCoUniv (Innovation Communication for Universities) – practice, aimed to make HEIs the centers of the innovative communications and to grow the understanding of the innovations and communications importance at university level;

- InCoSci (Innovation Communication for Scientific Society) – practice, aimed to promote communications between the scientific and research centers;

- InCoCorp (Corporate Innovation Communication) – encouragements and realization of the communications strategy in the innovations sphere;

- InCoEd (Innovation Communication in Education) – practice, aimed to grow the importance of the creative potential and innovations in the system of education.

This field communications creates the conditions for socio-economic ecosystem processes (Table 1).

Table 1. Types of processes in innovation ecosystem (based on the classification of base social processes by R. Park and E. Burgess)

Type of process	Meaning according to R. Park and E. Bergess	Manifestation in the high-tech industry
Cooperation	attempt to become a part of these groups as well as to regulate cooperative group life	cooperation in the framework of international projects
Competition	struggle between individuals, groups or societies for the possession of values, which stocks are limited and unequally distributed among individuals or groups	struggle for the top of value chains and for critical technologies
Adaptation	adoption of individual or group to cultural norms, values and standards of action of the new environment	adaptation to the dynamic innovation environment
Conflict	open struggle between individuals or groups in society or between nations (states)	different types of socio-economic conflicts
Assimilation	process of cross-cultural penetration through which individuals and groups come to shared by all participants in the process of general culture	internationalization of innovation
Amalgamation	biological mixing of two or more ethnic groups, after which they become one group	convergence of technologies
Maintenance of borders	boundaries between groups, destruction of the formal separation in the appearance of the general identification of members of the group	process safety management
Systematic linkages	all social groups that are within certain limits also need to create certain types of relationships with other groups of the society	strategic projects, creation of an effective innovation ecosystem

Practice has shown that the international interaction of clusters is effective tool for development [11]. In particular, one of the contemporary challenges for European cluster community is the task of development a significant number of world-class European clusters (world-class clusters). Solution which has been proposed Europa Inter Cluster is the formation of strategic cluster alliances. Specific proposals for the development of world-class clusters concentrated in White paper - detailed report, which describes the 3 challenges, 9 basic principles and 7 proposals.

So according to White paper three challenges faced by clusters of EU are follows:

1. Globalization requires that clusters develop holistic strategic vision to form their own value chain. You must take a position in emerging markets with high added value. It is possible for inter-sectoral clusters and clusters with a significant component of the services sector, for example, nanotechnology, new materials, "green" technology;

2. Necessity of internal consolidation: while finding its own niche in the global economy clusters need to strengthen their own inner core - sufficient internal dynamics, which provides a full innovation cycle (from idea to patent, from prototype to design, from production to market entry). The quality of the internal dynamics and a criterion of global competitiveness cluster;

3. Obtaining the effect of existing capacity: clusters at this time both feel the need to form a global strategy and internal consolidation. Faced with serious competition, clusters should be consolidated to form alliances in order to move from a culture of sharing (e.g., sharing of experience) and cultural cooperation (creation of temporary consortiums for the duration of the cluster program) and finally to the cultural community (formation constant groups of three or four clusters, complementary to each other in the production process, with a strong management team and a single overall strategy).

The benefits of international cluster cooperation:

1) to the business of the international cluster cooperation: a raised profile, access to knowledge (to use in new products and services), to new markets, key infrastructure, e.g. pilot plants, living labs etc, new international partners for collaboration

2) to other organizations in the cluster: a raised profile, access to knowledge, to new markets, new and wider customer base, new international partners for collaboration

3) to the cluster organization: a raised profile, new international partners for collaboration, new international partners for staff exchange, improved ability to benchmark performance

4) delivered to the region/member state by the cluster organisation: increased competitiveness and export performance by key businesses, increased access to potential inward investors, increased level of external funding utilised by the region/member state.

In the context of the internationalization of cluster development should consider two basic options:

- Connecting companies of cluster to global cluster projects of national (or transnational) corporations

- Interaction if a corporation is associated with several clusters located in different regions.

Analysis of successful international experience shows that joint inter-cluster projects have very positive impact on the development of clusters, and big private business can be a guide in their design and implementation.

So the development of high technology areas today is hampered by the lack of system planning and coordination (horizontal and vertical) of fundamental and applied research and development, in particular, carried out at the expense of budget funds. Intercluster interaction application allows to improve the performance of all actors in the chain by reducing the time of delivery under the following conditions:

- availability of modern infrastructure of technology transfer;

- business process reengineering;

- improvement of national standards system harmonized with international standards and recommendations.

Analysis of the stages of intercluster interactions should be based on the evolutionary strategy of the cluster (see Figure 2), which considers the differentiation of clusters based on their ability to "revive" the economy, intensity of the exchange of knowledge, innovation and capital between the cluster members.

Among the stages of the cluster should be highlighted:

- "hidden" stage, when there are certain features that are not yet involved, and their synergy is not yet implemented;

- stage of active functioning, where the clusters are able to fully realize their potential (ready to produce products more than it would have produced separately together all members of the cluster).

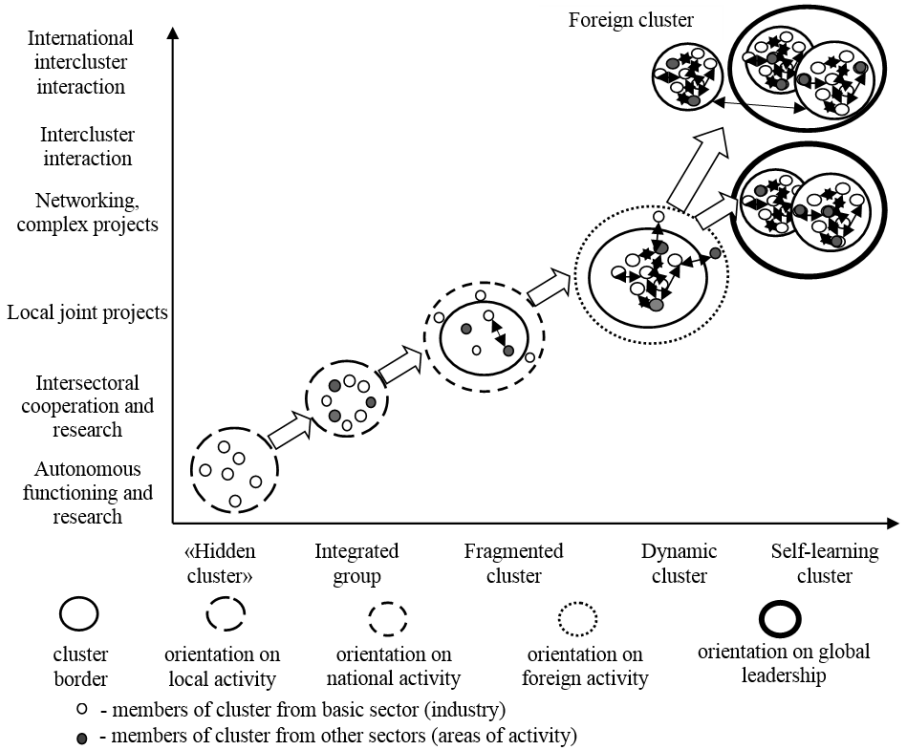


Figure 2. The evolution of high-tech cluster in the framework of the internationalization of innovation and technological development

Thus the highest form of inter-sectoral linkages can be considered as an integrated system of clusters as a system of technologically interconnected companies, organizations, research institutes, implementation, investment firms, infrastructure, financial institutions, which provides optimum development of integrated products and technologies.

One of the areas that require the using of new approaches to the management of cross-sectoral in a new way is space industry. It can be characterized by following features:

- wide intra-and inter-sectoral cooperation, a large number of subcontractors in the design, manufacture and testing of products;

- small series in production;

- diversity and complexity of technological processes that require research and experimental work;

- continuous, accelerated increasing demands for quality, reliability, service life of products;

- complexity, uniqueness and high cost of products.

On an example of the industry we can identify the basic problems of the innovation system, which consist in the management. Despite the fact that the infrastructure of innovation actually formed as existing researchers and scientists, innovation managers, investors, technology parks and incubators, etc. However, the results in the world rankings of the innovation system is not the best. This arises from the fact that the criterion for the

effectiveness of the innovation appears not the mere presence of the elements, and the level of efficiency of cooperation at different stages (design, implementation, use), as well as the appropriate development of all elements.

"Bottlenecks" significantly reduce the efficiency of the whole cycle. Also important is the interaction between the participants - streamlined transfer of intellectual property, competencies, capital, training, best practices of business and etc. This aspect requires to develop an objective criteria for product assessing, since in the absence of such criteria probability of non-productive use of resources (primarily the state budget) is quite high in situation when development plans are not met.

Basic factors in the development of cross-sectoral interaction space industry include:

- necessity for cross-sectoral strategic partnership for optimization of supply of resources and risk management;
- necessity for align technology parameters from the initial stages of development;
- ensuring process safety of projects.

So the main factor for the example of space device engineering is a systematic process connections (see Figure 3) and the factor of technological convergence, which provides intensive interaction between scientific and technological areas, a significant synergistic effect, considering the breadth and influence - from the atomic level of matter to smart systems and qualitative growth technological capabilities.

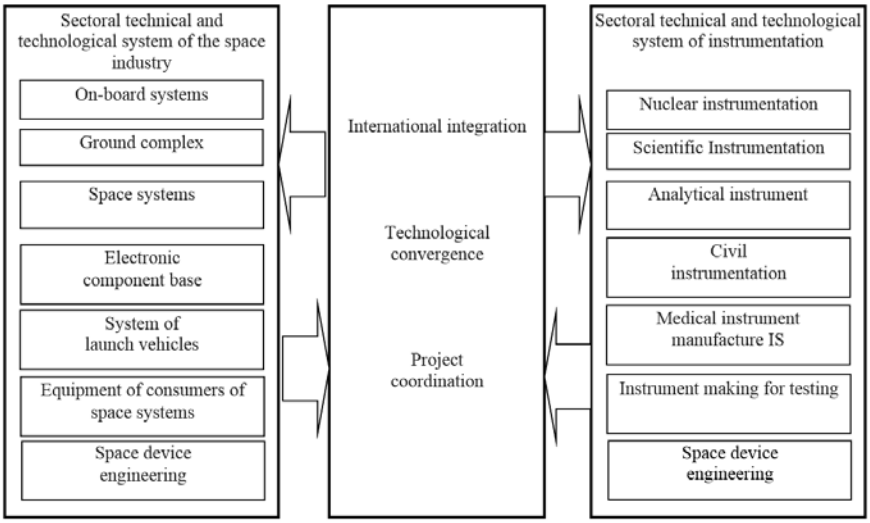


Figure 3. Scheme of the technological development of instrumentation industry

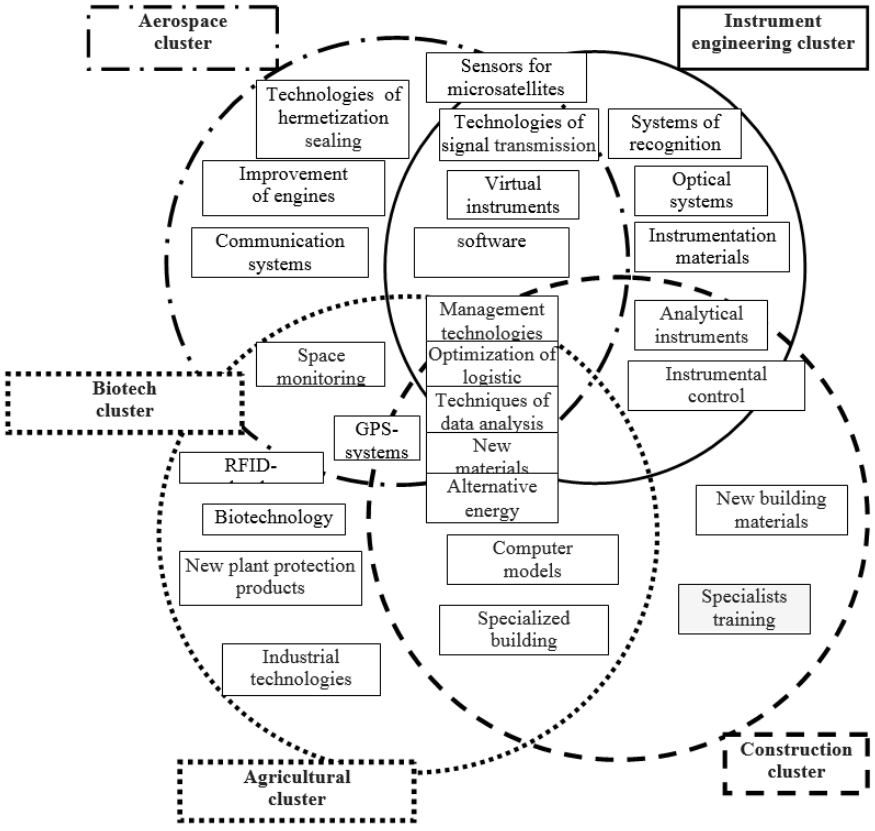


Figure 4. Potential structure of the regional cluster of Nizhnekamsk Municipal District of the Republic of Tatarstan

Effective tool to search for partners and geographical assessment of the current state of the initiative is European Cluster Observatory (www.clusterobservatory.eu/) [2], which provides statistical analysis and mapping of clusters across Europe, and this facilitates partnerships cluster organizations and cluster firms, acting as a full information service.

The results of our previous studies [8,9] show that the most effective cross-sectoral technology transfer achieved during cluster interaction.

On the example of the aerospace cluster and instrumentation cluster we illustrate the possibility of interaction with other clusters of specialization on the basis of cross-sectoral technology transfer (see Figure 4), which is based on the potential convergence of technologies and is able to solve complex problems that are common for several areas.

If we talk about management of development of the industry is organized in leading countries, particularly the USA, the production of space technology by private companies, and research in the field of space involved in both public and private organizations.

In this case it is possible to use a unique competence, strategy efficiency in an increasingly global economy and to improve the mechanisms of interaction between government and private firms in the financing of new space technologies and their next use for commercial effect (see Figure 5).

Participants of high-tech cluster must more fully consider the criteria of international involvement in the interaction with their counterparts from other regions or countries (see Figure 6).

Summary effect international effect can be calculated using the formula (1).

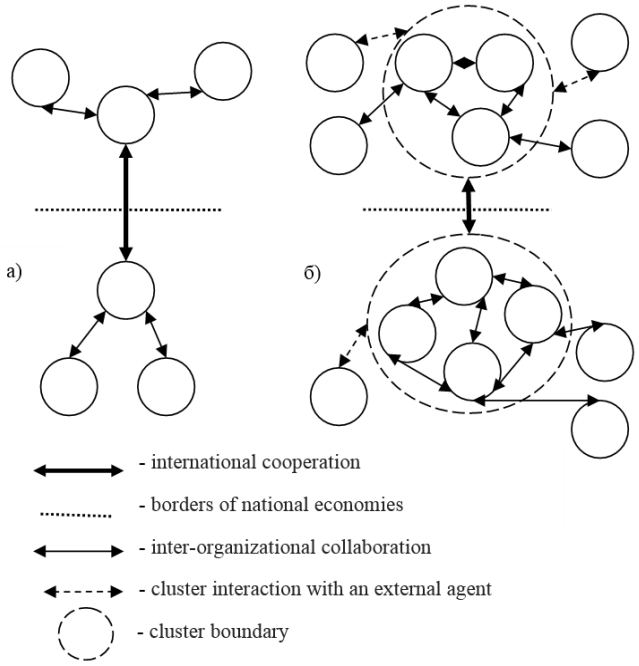
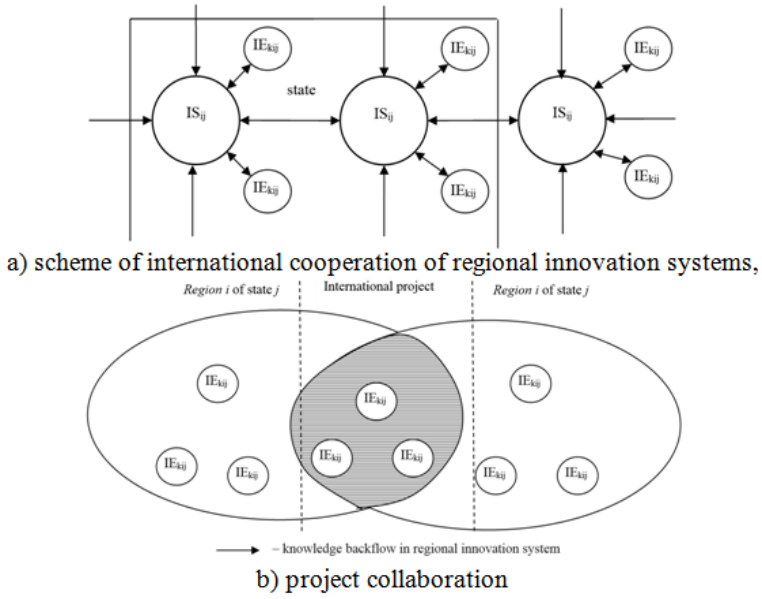


Figure 5. Compare of international innovation cooperation a) inter-organizational collaboration b) intercluster interaction



IS_{ij} – innovation system *of region i* of state *j*,
IE_{kij} – element *k* innovation system *of region i* of state *j*

Figure 6. Network international cooperation elements of the innovation system

$$\text{Sum E} = \sum_{l=1}^{L}\sum_{i=1}^{N}\sum_{j=1}^{M}(E_l((IS_{ij})\cup(IS_{ij})) - Tr_l - T_l) = \sum_{i=1}^{N}\sum_{j=1}^{M}\sum_{k=1}^{K}(E_l E((IE_{kij})\cup(IE_{kij})) - Tr_l - T_l) \quad (1)$$

where *Sum E* – cumulative effect of the integration of a specific innovation system in the global environment;

E_l – effect of participation in the network (project) l;

Tr_l – transaction costs of the Institute of administrative barriers;

T_l – transformation costs in industry in which the function IE_{kij}.

In this case based on the approach for the assessment of the amount of information the cumulative effect must meet the following condition:

$$\text{Sum E} \geq \log\frac{P_1}{P_2} \quad (2)$$

where P_1 and P_2 – probability of achieving the objectives of regional development before and after the implementation of the strategy of innovative development respectively.

The effectiveness of international integration can be evaluated using an innovative multiplicator, whose influence can be decomposed into three main components:

1) direct effects associated with the growth of production in the sector;

2) additional effects due to the development of inter-sectoral linkages;

3) the effects on the distribution of income, costs and risks.

4. Conclusion

Today in the developed countries there is a tendency to move away from the export of capital and resources to technology transfer. Thus there is a replacement of intensive development of the economy on innovation, based on the using of new knowledge and innovation as drivers of growth. In this case the internationalization of innovation is the key to success in global competition, which takes place in the creation and transfer of high technologies, and that clusters should be the engine of high-tech development.

Innovation clusters or areas of high technology develop on the base of the formation of inter-firm linkages within some region in order to reduce transaction costs, use of the local environment of industry and culture, enhance of innovation capacity. But in order to preserve the competitiveness of clusters, especially those that operate in high-tech, should use the strategy of internationalization, i.e. use of the advantages and resources of the international environment.

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